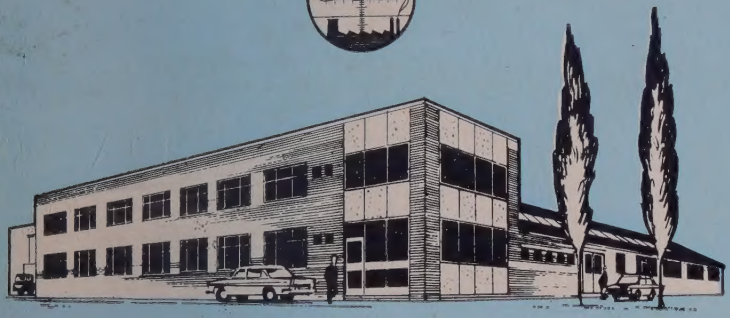
CAL 411



FARNELL

INSTRUCTION MANUAL
FOR

"S" SERIES
STABILISED POWER SUPPLY UNITS

ISSUE 2

FARNELL INSTRUMENTS LTD. SANDBECK WAY, WETHERBY, YORKS.
TEL. WETHERBY 2691/2/3/4

FARNELL INSTRUMENTS LTD.

THIS SPECIFICATION IS APPROVED
FOR USE IN THE CALIBRATION OF
COMPANY INSTRUMENTS.
6
CALIBRATION DEPARTMENT
C FACILITIES
DATE: 20.9.79
BRITISH AIRCRAFT CORPORATION, STEVENAGE

INSTRUCTION MANUAL

FOR

"S" SERIES
STABILISED POWER SUPPLY UNITS

FARNELL INSTRUMENTS LTD.
SANDBECK WAY, WETHERBY, YORKS. Tel. Wetherby 2691/2/3/4

CONTENTS

		Page No.
SECTION I	INTRODUCTION	1
SECTION II	OPERATION	2
SECTION III	CIRCUIT DESCRIPTION	4
SECTION IV	SPECIFICATION	6
SECTION V	INTERNAL ADJUSTMENTS ..	8
SECTION VI	TYPICAL PERFORMANCE AND APPLICATIONS	9
SECTION VII	MECHANICAL SPECIFICATION ..	18

SECTION I

INTRODUCTION

This manual covers the range of "S" series sub-units which consist of the following types : SSA, SSB, SSC, SSD, SSE, SSF, STA, STB, STD, STE, STF, SSB/H, SSE/H, SSF/H. The circuit diagram contained in the manual is for the particular unit type supplied.

The "S" series of stabilised power supply units consists of a number of single and dual output D.C. supplies in sub-unit form. The semi-conductor complement of these supplies is silicon throughout, permitting operation to 60°C at full specified output, and increasing linearly to 80°C as the current is derated to zero.

Output voltage is pre-set to a nominal voltage within the range 0–30V or 30–60V. Fine adjustment of at least 1V above or below the pre-set voltage is given by a trimmer potentiometer on the front panel.

Overload protection is provided by current limiting circuitry which reduces the output current on short circuit, but allows automatic voltage resetting when the overload is removed.

Cooling is by air convection so that provision should be made to allow air to flow freely into the bottom, and out of the top of the unit. If the unit is to be mounted onto a flat plate, ventilation holes should be punched in the plate or the unit raised by the spacers supplied.

The instruments will accept mains inputs of 210, 220, 230 and 240V, and by simple tap change on the transformer primary, 105, 110 and 115V 50/60 c.p.s. supply. Mains input is applied via a three way connector on one end, and the D.C. output is drawn from a terminal strip on the opposite end of the unit. Mains input and line fuses are fitted as additional protection.

Mains input and D.C. output are well separated for safety reasons in respect of the user and his equipment, and in this respect conform with G.P.O. Regulations.

SECTION II

OPERATION

Connection to the mains supply is via the three way input connector on the rear of the unit. Units are normally supplied for 240V operation, for other input voltages see the note on transformer connection.

D.C. output is taken from the terminal strip on the front panel of the instrument. Feedback terminals are provided to correct for the voltage drop along the connecting leads. Connections should be made from the remote end of the negative lead to the connection marked FEEDBACK—and similarly from the remote end of the positive lead to the FEEDBACK + connection. Where feedback connections are not required, output and appropriate feedback terminals should be linked at the terminal strip.

A terminal for remote programming of the output voltage by means of external resistance is provided. Notes on the application and limitations of this facility are in Section VI.

When not in use this terminal should be connected to the FEEDBACK — terminal.

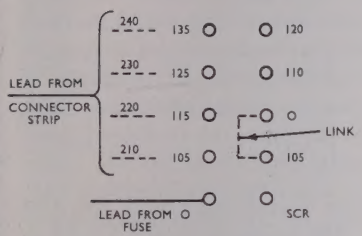
Each unit is pre-set to a voltage within the range 0–30V according to customers' requirements. Small adjustment of the output voltage is available by means of the O/P ADJUST trimmer potentiometer adjustable from the front panel.

NOTE.—Although more adjustment is available, for correct operation, not greater than ± 1V deviation from nominal voltage should be used.

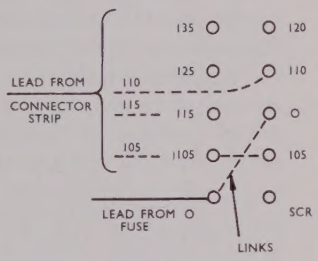
Should the current limit point need adjustment, the C/L ADJUST potentiometer is available on the front panel. This control is normally set approximately 10% in excess of the stated maximum operating current.

TRANSFORMER CONNECTIONS

210 — 240 VOLT CONNECTION



105 — 115 VOLT CONNECTION



SECTION III

CIRCUIT DESCRIPTION

The circuit employs series regulator transistors driven via emitter followers from a two stage differential amplifier which compares the voltage of a zener diode reference with a proportion of the output voltage derived from a resistive potential divider. The reference and amplifier sections are mounted on a printed circuit board which is common throughout the range. A change of two resistors and transformer tapping is required to change the output voltage. 2V variation is available from the trimmer potentiometer on the front panel of the unit.

The mains supply is connected to transformer MT1 via the input connector strip and fuse F1. The main secondary windings supply a bridge rectifier, reservoir capacitor system which provides the main unregulated D.C. line. The positive line is connected via the series regulator transistors to the positive output terminal. The negative line is connected via fuse F2 to the negative output terminal.

Supplies for the amplifier and reference section are derived from the auxiliary 36V secondary winding via rectifier diodes D1 and D2 and smoothed by capacitors C1 and C2. The unstabilised reference line across C1 and C2 is fed to zener diodes Z1 and Z2 through feed resistor R1. Z1 and Z2 provide a +10V – 0 – – 10V supply for the differential amplifier. R2, Z3, VT1 and R4 comprise a constant current source to feed the main reference zener diode Z4, and potential divider chain R9, R10 and T1.

The base of VT2, and the negative of Z4 are connected to the positive feedback terminal. Z4 therefore gives a voltage positive with respect to the positive output line. R9 is connected between the positive of Z4 and VT3 base. Signal voltage between VT2 and VT3 bases is amplified at their collectors, and applied to VT4 base. After amplification at VT4 collector the signal is applied to the emitter followers of the series regulator stage in such a sense as to oppose the original signal at VT2 and VT3 bases. The action of the loop is therefore to maintain zero signal between VT2 and VT3 bases. Output voltage is determined by

$$\frac{\text{Vref.} \quad (\text{R10} + \text{T2})}{\text{R9}}$$

Overload protection is provided by differential amplifiers VT6 and VT7. The base of VT6 is connected to the positive output terminal and the base of VT7 is connected to potential divider T2 and R18, connected between the series regulator emitter and the negative feedback terminal.

When output current is low VT7 is conducting since the voltage at its base is negative with respect to VT6 base, VT6 being cut off. As output current increases, the voltage across R23 increases and the junction of R23 and T2 becomes more positive, causing VT7 base to become more positive. With increasing load this process continues until the voltage between VT7 and VT6 bases approaches zero. At this point VT6 begins to conduct and VT7 to cut off. The voltage across R16 now begins to rise until D6 conducts and increases the drive at VT4 base. This increases the voltage across R13 and hence reduces the amount of drive available for the output regulator stages. At this point the output current limits and further increase in load causes the output voltage to fall. VT3 now cuts off, by the action of potential divider R9, R10 and T1. Also as output voltage falls, the voltage at VT7 base becomes more positive by the action of potential divider T2, R18. This causes VT7 to conduct less and VT6 to conduct more. VT4 is now driven further into conduction and the voltage across R13 increases, thus reducing the drive available for the output regulator stages. In the absence of R19, this process would be regenerative, i.e. as soon as the limit point was reached, the output voltage would fall immediately to zero. R19 increases the slope of the output V/I characteristic in overload to produce the overload characteristic shown in Fig. 9. With increasing overload the action of the circuitry is to reduce output current until at short circuit the current output is less than $\frac{1}{4}$ of the maximum output current. This ensures that the unit will reset into normal loads, once the overload is removed. The point at which initial current limit occurs is set by T2.

SECTION IV

SPECIFICATION

MAINS INPUT

Standard—240V, 50/60 c.p.s.

By internal link changes : 210, 220, 230V, 50/60 c.p.s.
105, 110, 115V, 50/60 c.p.s.

OUTPUT VOLTAGES AND CURRENT RANGES

	Type	Output Voltage	Output Current
SINGLE OUTPUT	SSA	0–25	1A
		25–30	½A
	SSB	0–25	2A
		25–30	1A
	SSC	0–15	3A
		15–30	2A
	SSD	0–15	4.5A
		15–30	3A
	SSE	0–15	7.5A
		15–30	5A
	SSF	0–15	15A
		15–30	10A
TWIN OUTPUT	STA	0–25 each o/p	½A each o/p
		25–30 ,, ,,	¼A ,, ,,
	STB	0–25 ,, ,,	1A ,, ,,
		25–30 ,, ,,	½A ,, ,,
	STD	0–15 ,, ,,	2A ,, ,,
		15–30 ,, ,,	1.5A ,, ,,
	STE	0–15 ,, ,,	3.5A ,, ,,
		15–30 ,, ,,	2.5A ,, ,,
	STF	0–15 ,, ,,	7.5A ,, ,,
		15–30 ,, ,,	5A ,, ,,
SINGLE OUTPUT HIGH VOLTAGE	SSB/H	30–60	1A
	SSE/H	30–60	2.5A
	SSF/H	30–60	5A

Mains Variation Tolerated	±10%
Output change for 10% mains change, short term	less than 5mV
Output change for 0-full load change (output resistance effect)	less than 5mV
Ripple Voltage at full load	less than 500μV peak to peak.
Overload protection	Current limiting with reduction of output current on increasing overload.
Maximum Temperature for operation at specified full load	60°C.
Maximum Temperature for operation at half specified full load	70°C.
Maximum Temperature for operation at no load	80°C.

SECTION V

INTERNAL ADJUSTMENT

Units are set on test to a given fixed output voltage. The setting is performed as follows :—

(1) Resistor R10 in the feedback potential divider chain sets the output directly, its value being :—

$$R = \frac{2.2}{Vref} \times (Vo - 1) \text{ K ohms.}$$

Where Vref is the voltage across the reference zener diode Z4. For voltages below 1V, R10 should be a wire link.

(2) Resistor R18 sets the point at which current limit occurs, its value being given by voltage output $\times$ 0.5K ohm. Final setting of the current limit point is made by adjustment of T2 on the front panel. The value of current limit point should be set to approximately 10% in excess of the maximum output current required in order to avoid modification of the voltage regulation characteristic by the current limit circuitry.

(3) Transformer tap selection should be made according to the attached graphs for the A & B, C & D, E & F units. The main secondaries are connected in parallel for the single output units, one per channel for the twin output units, and in series for the high voltage units.

SECTION VI

TYPICAL PERFORMANCE AND APPLICATIONS

1. *VOLTAGE PROGRAMMING*

All units may be programmed by means of external resistors to any voltage below the voltage to which it was originally set. Since this involves increased dissipation on the series regulator elements, the output current must be derated with reduction in output voltage. The safe operating area for a unit set to Vo and Imax is given in Figure 4.

The lower limit on voltage and current is provided automatically by the overload protection circuit.

The programming terminal is normally linked to the negative feedback terminal on the front panel. In order to programme the unit externally this link should be removed, R10 should be removed from the main circuit board, and a link substituted in its place. T1, the "voltage adjust" trimmer on the front panel, should be turned fully anti-clockwise. The programming resistor should now be connected between the "Prog" terminal and the "Feedback —" terminal. The value of programming resistor is given by :—

$$\text{Rprog} = \frac{2.2}{5.1} \times \text{V required, K ohms.}$$

The tolerance on V required for an accurate Rprog is ±6%. In order to obtain greater accuracy the voltage of the reference zener diode Z4, V ref. must be determined. Rprog is now given by :—

$$\text{Rprog} = \frac{2.2}{\text{Vref}} \times \text{V required, K ohms.}$$

The tolerance on V required for an accurate Rprog is now ±1% plus the tolerance on the Vref measurement.

2. *SERIES OPERATION*

Units may be connected in series, but diodes of current rating equal to the unit maximum output current must be connected across the output terminals, cathode to positive, on the single units. The twin supplies are fitted with these diodes as standard. On overload it may be found necessary to disconnect the load momentarily in order that the series combination will reset to the original output voltage.

3. *PARALLEL OPERATION*

Units which are set to approximately the same output voltage may be connected directly in parallel. On increasing load the unit having the highest output voltage will carry the load until it current limits, thereafter the unit having the next highest voltage will supply the extra current until it limits and so on. A typical output characteristic for a parallel combination of three units is shown in Figure 5. The characteristic shows a series of descending steps in output voltage at the current limit points of individual units, the amplitude of the step depends on how closely the output voltages have been set and it may not be possible to adjust this to better than 50mV.

It is recommended that not more than three units are paralleled in this way.

4. *TYPICAL PERFORMANCE*

Stability

Output voltage variations are due, in the main, to the following causes :—

(a) Load change,
(b) Mains supply change, or
(c) Component temperature change.

(a) *Load Change*

(i) Steady Load.—For a change in steady load from zero to full load, the typical output change is from 1mV at 1 volt output, increasing linearly to 5mV at 30 volts output.

(ii) Transient Response.—The typical response to a pulsed load is shown in Figure 6.

(iii) Output Impedance.—For alternating load superimposed on a steady load, the output impedance of the supply increases with frequency due to the fall off in gain of the amplifier until it is determined only by the capacitor across the output terminals. A typical output impedance/frequency curve is shown in Figure 7.

(b) *Mains Supply Change*

Short term mains variations of up to $\pm 10\%$ give corresponding variation of 0.02% on the output. Surges on the mains supply in the form of short rise time pulses can be fed on to the output by stray capacity. Where these conditions exist a capacitor suppressor filter should be connected in the mains lead.

(c) *Component Temperature Change*

Output variation is caused by component value changes due to temperature change. The temperature change can be (i) as a result of ambient change, or (ii) as a result of unit internal temperature change, caused by changing internal dissipation from a change in load or supply to the unit.

(i) Ambient Change.—The typical temperature coefficient of output voltage is 0.02% per degree centigrade of ambient change.

(ii) Internal Change.—Figure 8 shows typical output variations caused by mains change and load change plotted against time.

5. *OVERLOAD PROTECTION*

Typical output voltage/output current curves are shown in Figure 9. The position of the current limit once set will remain typically within 5% of the setting over the temperature range 0–60°C.

6. *MAXIMUM AMBIENT TEMPERATURE FOR OPERATION*

All units will supply full output to 60°C ambient. By derating the output current to zero linearly with temperature from 60°C, the units may be operated up to 80°C (Figure 10).

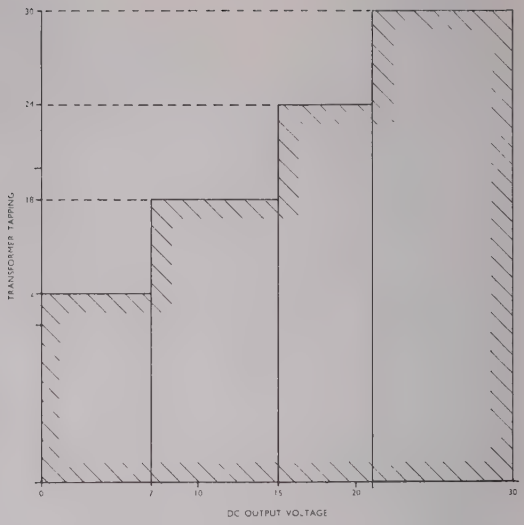


Fig. 1. SSA, SSB, STA & STB Transformer Tap required for given Output Voltage

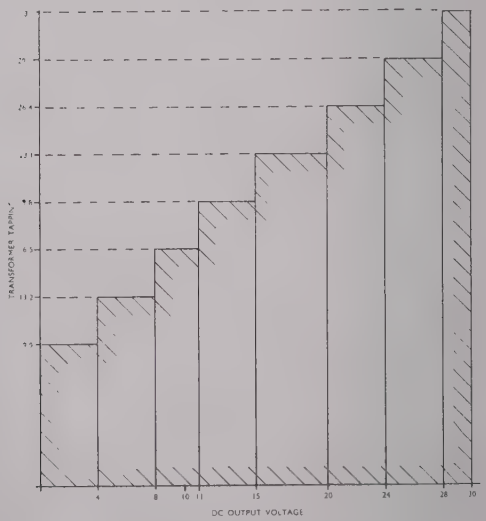


Fig. 2. SSC, SSD & STD Transformer Tap required for given Output Voltage

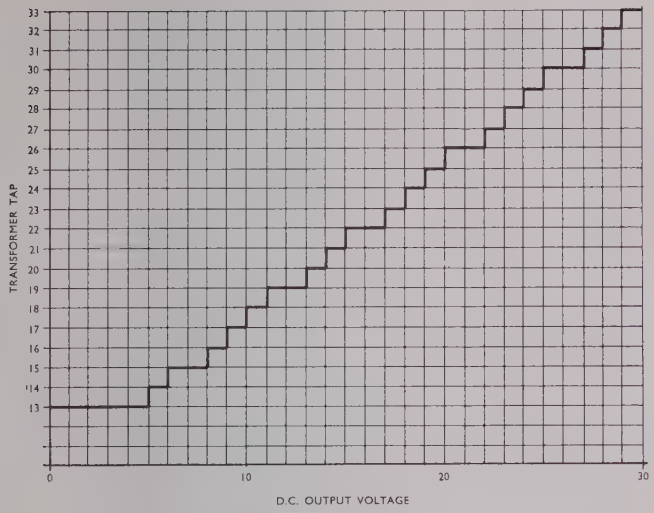


Fig. 3. SSE, SSF, STE & STF Transformer Tap required for given Output Voltage

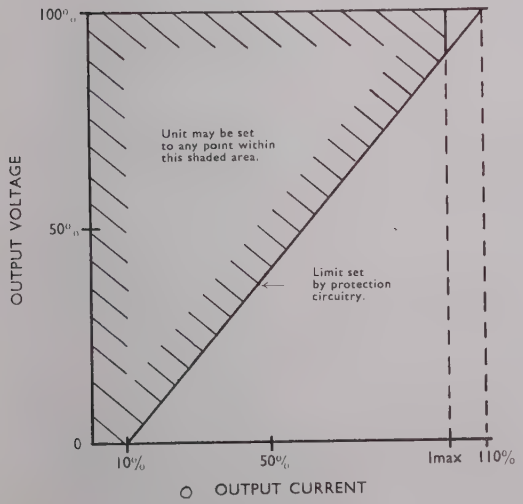


Fig. 4. Permissible area of operation in Programmed Mode

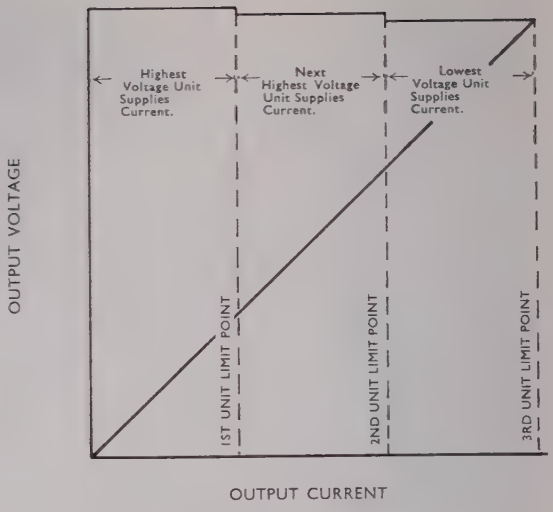

OUTPUT VOLTAGE
Highest Voltage Unit Supplies Current.
Next Highest Voltage Unit Supplies Current.
Lowest Voltage Unit Supplies Current.
1ST UNIT LIMIT POINT
2ND UNIT LIMIT POINT
3RD UNIT LIMIT POINT
OUTPUT CURRENT

Fig. 5. Parallel Operation

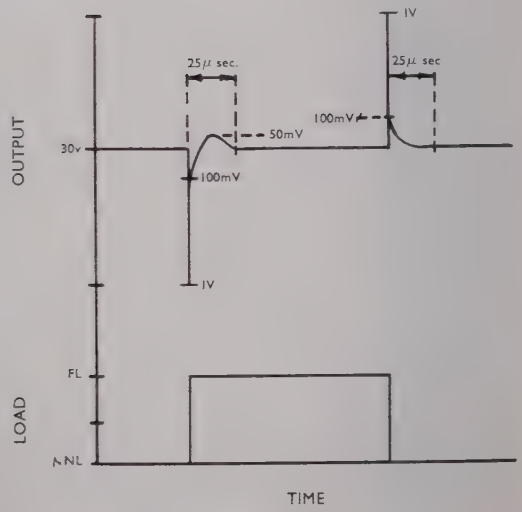


Fig. 6. Pulse Response

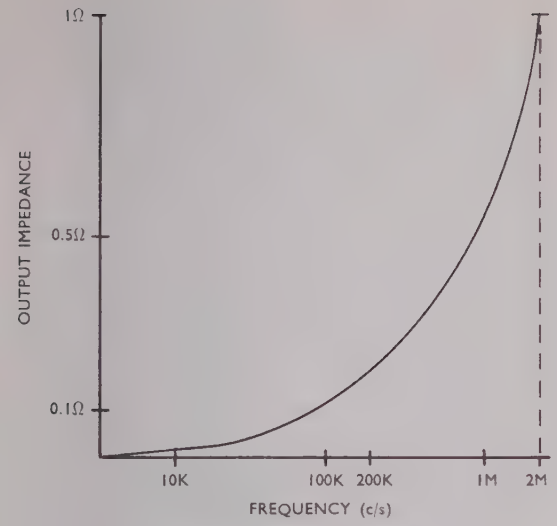


Fig. 7. Output Impedance

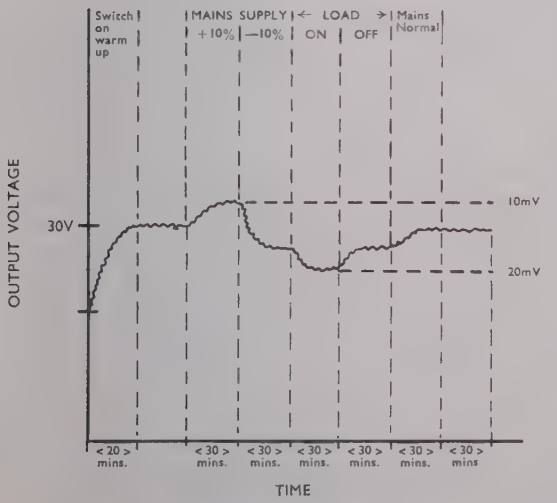


Fig. 8. Typical Output Voltage Variation against Time

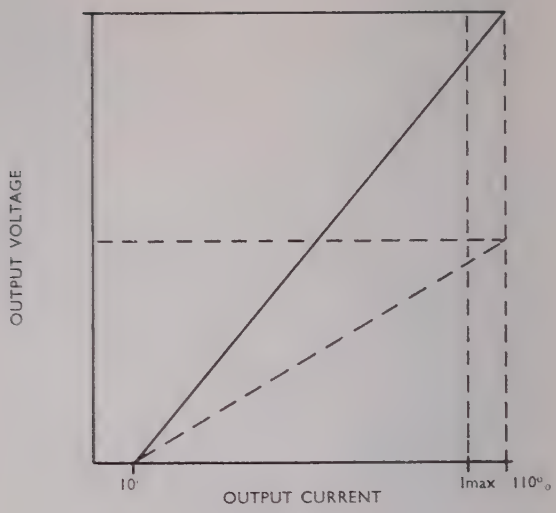


Fig. 9. Output Protection

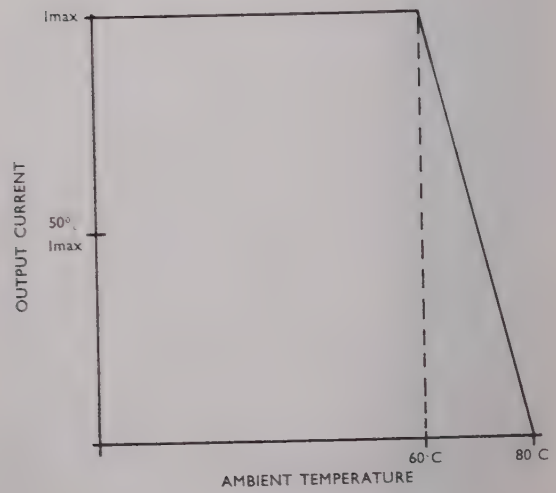


Fig. 10. Derating of Output Current with Ambient Temperature

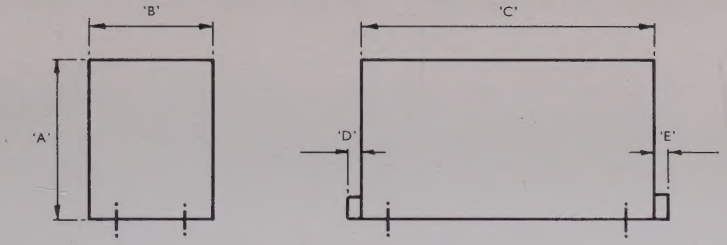
ERRATA AND ADDENDA

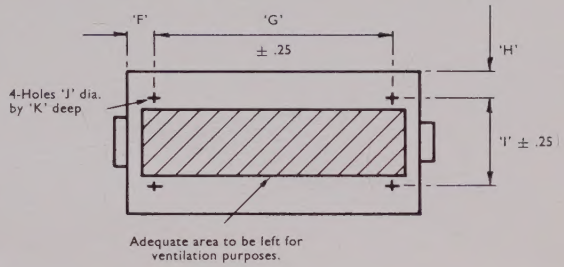
ALTERNATIVE COMPONENTS TO THOSE LISTED ON CIRCUIT DIAGRAM MAY BE USED IN THE EVENT OF SUPPLY DIFFICULTIES. MAJOR CHANGES TO THE DESIGN OR MANUAL ARE LISTED BELOW.

OVERALL SIZES AND FIXING DIMENSIONS FOR "S" RANGE OF POWER SUPPLY UNITS.

Type.	A	B	C	D	E	F	G	H	I	J	K	Weight Lbs.	Weight Kgms.
SSA	126	82	178·4	10	19	23·2	132	5	72	4BA	6	4½	10
SSB	126	110	242·4	11	19	23·2	196	5	100	4BA	6	7¾	17·1
SSC	158	110	242·4	11	19	23·2	196	5	100	4BA	6	8½	18·8
SSD	158	124	242·4	11	19	23·2	196	5	114	4BA	6	10¼	22·7
SSE	188	134	356·4	11	23	23·2	310	6·59	120·83	2BA	8	19¾	43·6
SSF	188	228	340·4	30	23	23·2	294	47	134	2BA	8	33½	74
STA	126	120	178·4	10	19	23·2	132	5	110	4BA	6	5¼	11·6
STB	126	120	242·4	10	19	23·2	196	5	110	4BA	6	7¾	17·1
STD	158	158	242·4	11	19	23·2	196	5	148	4BA	6	11¼	25
STE	188	134	356·4	11	23	23·2	310	6·59	120·83	2BA	8	20½	45·5
STF	188	228	340·4	11	23	23·2	294	47	134	2BA	8	34¼	76
SSB/H	126	110	242·4	11	19	23·2	196	5	100	4BA	6	7¾	17·1
SSE/H	188	134	356·4	11	23	23·2	310	6·59	120·83	2BA	8	19¾	43·6
SSF/H	188	228	340·4	30	23	23·2	294	47	130	2BA	8	33½	74

All Dimensions in m.m.


'B'
'A'
'C'
'D'
'E'


'F'
'G'
± .25
'H'
4-Holes 'J' dia.
by 'K' deep
'I' ± .25
Adequate area to be left for
ventilation purposes.

Fredk. Duffield & Sons Ltd.,
421, Kirkstall Road, Leeds, 4.